Ancient Sources of Energy

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Introduction

Teaching is my passion. Every August, I am excited to meet my new group of students. This year is not an exception. I have been fortunate enough to have taught at only two schools during my twenty-four years of teaching, all in the same district. For nineteen of those years, I have taught at West Park Place Elementary School. During those years, I have taught both third and fourth grade, the latter being my position for the last nine years. Energy and Engineering Design are two core ideas from the fourth grade Next Generation Science Standards (NGSS). This unit is to help strengthen and build upon student understanding of the history of engineering designs relating to energy.

West Park Place Elementary School is part of the Christina School District, located in Newark, Delaware and is within walking distance of the University of Delaware. It is a small school of approximately 370 students from kindergarten to fifth grade. West Park is home to many programs that contribute to the diversity of the school: Delaware Autistic Program (DAP), Realistic Educational Alternatives for Children with Disabilities (REACH), English Language Learners (ELL), and Montessori Academies at Christina (MAC). According to the school profile for 2014-2015 school year as reported by the Delaware Department of Education, about 15% of West Park's population are English Language Learners (ELL), representing many different cultural backgrounds. West Park's population is comprised of 19% African American, 16% Asian, 11% Hispanic, 48% White and 6% Multi-Racial. The low income students served at West Park comprise 34% of the population. In addition, special education students with the exception of REACH and DAP are integrated into the regular classroom setting. Special education students make up 8% of the West Park population.

Since we are such a small school, our fourth grade team is made up of two classrooms. I am the team leader for fourth grade and teach all subjects: reading, writing, math, science and social studies. This is my second year participating in the Delaware Teacher Institute (DTI) program. A love of history and science spurred my decision for taking ***Ancient Inventions*** as my second year DTI seminar.

Rationale

The Next Generation Science Standards are just beginning to be introduced in the elementary school curriculum. Currently, our district has four science units that are taught during fourth grade: Land and Water, Sky Watcher, Electricity and Magnetism, and

Structures of Life. Kits have not yet been developed to coordinate with the NGSS. The expectation is that we begin to include elements of the NGSS into our current units. I feel this is the perfect opportunity to create lessons and activities that incorporate the NGSS into one of my units. In thinking of Ancient Inventions, I felt that Electricity and Magnetism would be a good fit. In looking at the NGSS that coincide with this unit, I found standards relating to Energy and Engineering Design. Students at this age, have a difficult time persevering through problem solving. This is one of the mathematical practices that would also fit into this unit. Through my DTI course, Ancient Inventions, I have learned that humans designed many complex machines and pieces of technology without the resources and tools that we have today. They persevered and used creativity to invent new ways to make life simpler. Today we have so many resources and tools available to us that we have lost some of the creativity of the past. I want students to put themselves in ancient times and use their creativity to design and engineer new ways to solve problems. I want them not to be afraid to take risks. How do I get my students to use their creativity and ask questions that guide their own learning? My students usually ask for help as soon as they get stuck instead of persevering and exploring their own ideas to try to solve a problem.

In developing an idea for my unit, I decided to focus on ancient inventions that created sources of power from the water wheel/turbine to the Baghdad battery. Our current FOSS (Full Option Science System) unit on Magnetism and Electricity focuses on how magnets interact, the force of attraction between magnets, building a complete circuit and a test circuit to test objects for conductivity, building and defining characteristics of series and parallel circuits, building an electromagnet and observing the interaction between the electromagnet and objects, and solving circuitry problems. I want to build students' knowledge of the history of electricity and magnetism as well as how ancient scientists and inventors made discoveries and found new ways to use their new found knowledge. At the beginning of the unit, students are traditionally given a bulb, wire and battery and told to explore to find a way to use the three materials to make the bulb light. Students get frustrated very easily when they can't make it light right away. They want hints. They always enjoy the activity and are so excited when they finally discover a way to make the bulb light. My goal is to start my unit with this idea to get kids problem solving and exploring-inventing ways to make a bulb light with only the given materials. Students will continue to explore and learn about different types of circuits and magnetism as well as other sources of power. I want to end the unit with a STEM design challenge. This unit will be designed for fourth grade but can be adapted to fit other grade levels. It will address reading, writing, speaking and listening standards in addition to science standards. The reading standard that will be addressed is Reading: Informational Text 4.3 that states students will explain events, procedures, ideas or concepts in a historical, scientific, or technical text, including what happened and why based on specific information in the text. It will be addressed through various readings throughout the unit. Writing standard 4.10, write routinely over extended time frames and shorter time frames for a range of tasks, purposes and audiences, will be addressed throughout the unit through writing activities in which students will explain their design process and observations during activities. Throughout the unit, students will collaborate with peers, present information to both small and large groups and participate in both small group and whole class discussions, addressing speaking and listening standard 4.1. One science standard addressed in the unit is NGSS Energy 4-PS3-2, make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. Another science standard addressed is NGSS Energy 4-PS3-4, apply scientific ideas to design, test and refine a device that converts energy from one form to another. Finally, I want to include a design process in my unit addressing NGSS Engineering Design 3-5-ETS1-3, plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Content

There are four forces that scientists have found that control the universe. They are gravity, strong nuclear force, weak nuclear force and electromagnetic force. The weakest force, gravity, pulls objects towards each other. The strongest force, strong nuclear force, joins the atomic nucleus together. On the other hand, the weak nuclear force generates radioactivity in certain materials. The electromagnetic force is accountable for electricity, magnetism, light and heat. Since magnetism and electricity are closely related, I researched the history of both concepts. I decided to focus on magnetism and electricity for my research since they are closely related as well as other ancient and modern sources of power, including the water wheel, battery, turbine, windmill, steam turbine, steam engine, and solar power.

Magnetism

One of the earliest stories or legends about how magnetism was discovered dates back about 4000 years ago. It involves an old Cretan shepherd named Magnus. The legend says that Magnus was herding his sheep in an area of Greece named Magnesia. He was standing upon a large black rock and suddenly his staff and the nails in his shoes became stuck to the rock. He then dug into the earth to find an earth material called lodestone. Lodestone contains magnetite which is a naturally magnetic material. The type of rock was called magnetite after either Magnus or Magnesia where it was found.

The Greeks or the Chinese made the earliest discoveries of the properties of lodestone. The writings of Lucretius and Pliny the Elder (23-79 AD Roman) contain stories of magnetism in the first century B.C.E. They mentioned the magical powers of magnetite. Pliny wrote about a hill that was made of stone and attracted iron. People were very superstitious when it came to magnetite for several years after its discovery. They thought its magical powers included healing the sick, frightening away evil spirits and destroying ships made of iron. It was soon discovered that magnetite not only attracted objects but when floated on top of water in a shape of a needle, it pointed north or south. The earliest compass was soon invented.

In 1269 Peter Peregrinus tried to separate fact from fiction in regards to magnetite. He began to write down everything that was known about magnetite and proven. Later in the 1600s, William Gilbert began to conduct experiments with magnetite. He was the first to discover that the Earth was a giant magnet. He also found that the two ends of a magnet always behave differently. He decided to call the two ends the north and south poles. Gilbert also discovered that opposite poles attract each other and like poles repel each other. This also led him to think that the Earth had a north and south pole of its own. It wasn't until 1820 that Hans Christian Oersted discovered that magnetism was related to electricity by placing a wire with an electric current running through it close to a magnetic compass which caused the compass needle to redirect.

Electricity

The Greeks were the first to investigate electricity several hundred years B.C.E. Thales of Miletus wrote about his discovered that rubbing a piece of amber with cloth caused amber to have the ability to attract small pieces of straw, thus discovering static electricity. In 1600, William Gilbert first used the term electricity which came from the Greek word for amber, electron. He also used the terms electric force, magnetic pole and electric attraction. Sixty years later, Otto Von Guericke created a machine that made static electricity. Robert Boyle discovered in 1675 that electric force could be sent through a vacuum, thus observing attraction and repulsion properties. Conduction of electricity was discovered in 1729 by Stephen Gray. The positive and negative forms of electricity were introduced by Charles Francois du Fay, although he called them resinous (-) and vitreous (+). Ben Franklin and Ebenezer Kinnersley were the first to call them positive and negative forms. Later in 1745, the Leyden jar was created by Peter van Musschenbroek. The Leyden jar was an electrical capacitor that stored static electricity. By 1747, Ben Franklin began experimenting with static electricity, and he began to think that there could be an electrical fluid that may be made of particles. It was also during this time period that William Watson discharged a Leyden jar through a circuit. This began the understanding of circuit and current. Also, the conductivity of objects was studied by Henry Cavendish. In 1752, Ben Franklin discovered the lightning rod, proving that lightning was electricity. Although batteries were invented much earlier, the first electric battery was created in 1800 by Alessandro Volta. He also discovered that electricity could travel over wires. By 1816, the U.S. had its first energy utility company, Baltimore Gas and Electric (BGE). It was called the Gas Light Company of Baltimore and it was formed to light the streets of Baltimore. The 1820s brought about the first electric motor and the electromagnet.

Water Wheel

The exact date and origin of the waterwheel is not known. What historians do know about the water wheel is that it was used in Greece several centuries B.C.E. and in the Roman Empire for pumping water from mines. Historians also believe that water wheels were used in ancient China in the first century. They were also used in Europe during the Middle Ages as the main source of power for driving large machines. Water wheels were used in the mills that ground grain into flour, and were also used in metal foundries and to drive air blowers for the smelting of iron, for the crushing of rock, and for the hammering of flax leaves to make paper. The problem with water wheels was they were limited to areas that had a water source and sloped land. Many of the areas such as mines that needed the water wheels as a source of power for their machines were not of suitable terrain. Figure 1 below shows and example of a water wheel used as a stamping battery. A stamping battery was used in mines to crush the minerals. The one depicted below crushed ore. The stamping set was sometimes called a "battery". Stampers were used by the Ancient Greeks in Hellenistic times (321-31 B.C.E). There are two types of water wheels-undershot and overshot. In an undershot water wheel, the wheel sits in the water and the flow of the water turns the wheel. In an overshot water wheel, water flows above the wheel and drops onto the paddles or buckets to turn the wheel. The overshot wheel is more efficient since gravity also plays a part in turning of the wheel, and it does not rely on the velocity of the water running under the wheel. Water wheels were later replaced by steam power during the Industrial Revolution. The technology has been brought back more recently in water powered turbines to create hydroelectricity.

Battery

The earliest known battery was the Baghdad battery. In 1936, workers building a railway near the city of Baghdad came upon an ancient tomb. Archeologists identified it as belonging to the Parthian Empire because as of 129 B.C., the Parthian Empire had acquired land up to the edge of the Tigris River near Baghdad. One of the artifacts discovered in the tomb was a clay jar or vase with a copper cylinder, an iron rod and an asphalt stopper. The artifacts discovered were corroded with some type of acid-possibly wine or vinegar. It is unknown what the batteries were used for. Wilhelm Koenig, the archeologist making the discovery, believed they could have been used for metal plating.

After World War II, an American engineer, Willard Gray, created a replica of the battery by filling a jar with grape juice; he was able to produce 1.5-2 volts of power. In the 1970s, a team of German scientists were successful in using a string of replica batteries to electroplate a thin layer of silver, thus supporting Koenig's theory. Walter Winton of the Science Museum in London examined the jar when he visited Baghdad. He concluded:

> "Put some acid in the copper vessel-any acid, vinegar will do-and-hey presto! - you have a simple cell which will generate a voltage and give a current of electricity. Several such cells connected together in series would make a battery of cells which would give enough current to ring a bell, light up a bulb or drive a small electric motor."[1]

Wind Energy

People have been using wind energy since early recorded history. Sails were used to catch the wind and propel boats along the Nile River in 5000 B.C. This led to the use of sails in a wind powered device called a windmill. It was used to help the Persians pump water for simple irrigation of agricultural land and for drinking water and grind grain between 500 and 900 A.D. The Chinese also used wind powered gain mills in 1200 A.D. The first windmills had sails that spun horizontally. The use of windmills spread from Persia to other areas of the Middle East. The windmills were used mostly for food production (grinding of grain). As sail design became more advanced, so did the windmills. They became more powerful as they changed the design of the sails to catch the wind more efficiently. These windmills had sails that spun vertically and more closely mirror the modern windmill design. Around 1000 A.D., technology utilizing wind power spread north to European countries such as The Netherlands, where windmills were adapted to help drain lakes and marshes in the Rhine River Delta. Between 1300 and 1800 A.D., the windmill design in Europe was more like the traditional windmill design we see even today. The designs were mostly likely developed to from the early water wheel designs. The technology that used water power to grind grain was also used with wind mills. The only evidence of windmills being used by the Greeks came from a creation by Hero of Alexandria, who later invented the first steam turbine. His invention was "clearly a toy, but why did nobody (apparently) see its potential as a power source?"[2] In order to be considered a power source, it would have to replace manpower or animal power. It could be that his design was not thought to be powerful enough and possibly, no one tried creating larger windmills at this time to generate enough power.

Steam Turbine

A turbine is a machine in which a wheel or rotor is made to rotate by fast-moving flow of water, steam, gas, air or other fluid to create continuous power. Transportation and the industry were revolutionized by the invention of the steam engine in the nineteenth century. The modern invention of steam power is the rediscovery of something learned two thousand years earlier. Heron Alexandrinus, also known as Hero of Alexandria, was a Greek mathematician and engineer from the first century who was the first inventor of a steam turbine. It was thought to be a step away from the steam engine. His invention was called the aeolipile, named after Aiolos, God of the winds. It was a sphere that could rotate on its axis. A large, sealed pot of water was positioned over some type of heat source like a fire. As the water in the pot boiled, steam would rise into two pipes that were attached to a sphere. There were two more pipes attached to the sphere where steam could escape. This would cause the sphere to spin at great speed. The principle involved in Heron's invention is the same as modern jet propulsion. Unfortunately, his invention was forgotten and not used properly until 1577, when the steam engine was invented by Taqu al-Din, a philosopher, astronomer and engineer.

Solar Energy

Dating all the way back to the 7th century B.C., people were using the sun's rays to make fire or to light torches. They used magnifying glasses or mirrors to concentrate the sun's rays on a particular object or area. It wasn't until the 1st -4th Century A.D. that the Chinese began using south facing windows to trap the sun's heat and warm their bath houses. Sunrooms in houses and public buildings became popular. Some historians believe that Archimedes used solar energy to destroy enemy ships by using a heat ray. This was supposedly mirrors that were positioned to aim the sun's rays to create fire.

Inventors during ancient times, created machines to make tasks easier long before they understood the principles behind why their machines work. Designs and drawings were made for some of these inventions long before they were created. The question is why did it take so long for technology to advance if these designs were created so long ago? How were they able to think so creatively? During my coursework for my Ancient Inventions class, our group visited the University of Delaware library. We had the opportunity to explore many ancient writings from the special collections section of the library. Seeing the designs of daVinci that he created long before the actual inventions was amazing. It is my hope that I can inspire some of that creativity in my students through the activities and lessons that I have planned for my unit.

Classroom Activities

Activity One- Complete Circuits

Essential Questions:

What is a complete circuit?
What are parts of a bulb?
What are parts of a complete circuit?

Essential Outcomes:

Students will be able to create a complete circuit to make their bulb light using given materials. Students will be able to identify more than one way to make a complete circuit.

Materials:

bulb, battery, wire, diagram of a bulb

Instruction:

Students will be given a bulb, battery and a wire. They will be presented with the task that they only have the 3 objects and can they make the bulb light? Can they find more than one way? Students will be asked to draw a diagram of any ways they have found to make their bulb light.

After investigation and sharing of results with the whole group, students will be posed with the question for discussion of why did the materials need to be connected in that way? Students will also be shown a diagram of a bulb so they can see where the wires are inside the bulb to understand the flow of the electric current from the battery to the bulb.

Activity two- Series Circuits

Essential Questions:

What is a series circuit?
How does a battery work?

Essential Outcomes:

Students will be able to create a battery using a lemon or potato. Students will be able to create a series circuit using lemon batteries or potato batteries connected in a series to light a bulb. Students will determine which has greater power-lemon battery or potato battery.

Materials:

several lemons, several potatoes, zinc nails, copper nails (or pennies), wires with alligator clips, LED bulbs

Procedure:

Students will be divided into groups. Groups will either be given 2 potatoes or 2 lemons. They will also be given 3 wires with alligator clips on the ends, 2 zinc nails and 2 copper nails or pennies, and a LED bulb. If using pennies, a slit will need to be made in each lemon or potato to place the penny. If using a copper nail, a copper nail and zinc nail will need to be placed in each potato or lemon in such a way that they do not touch each other. Connect an alligator clip to the penny of one, then connect another alligator clip to the zinc nail of another. The opposite end of that alligator clip gets connected to the penny or copper nail of the next lemon or potato. Finally connect the third alligator clip to the zinc nail of the second potato or lemon. This will leave an alligator clip at each end of the series. Each alligator clip will then be connected to a wire on the LED bulb. Students will then compare which bulb is brighter to see which generated more electricity-lemon or potato. You can find several videos on YouTube to watch for explanation of how the lemon battery or potato battery works.

Activity 3: Solar City

Essential Questions:

What are alternative sources of power?
What is a series circuit?

Essential Outcomes:

Students will understand alternative sources of power and why these are necessary for the future. Students will build a solar city using solar panels connected in a series circuit.

Materials:

mini solar PV panels ($10-$30 each-search online for "small solar panel" such as TuffStuff at http://www.toughstuffonline.org), piece of foam core board cut into different size rectangular pieces for different types of buildings, cardboard for plot of land (suggested 24" x 24") small alligator clamps, small Christmas tree lights (individual) or any individual bulb from a hobby/craft/electronics store that can be hooked up in the circuit, graph paper, pencils, acrylic paint, duct tape, utility knife to cut foam board, newspaper to cover table while painting/gluing, hot glue gun or glue sticks, voltmeter (optional)

Procedure:

Pose to students: How do we use energy at school? Where do we get our electricity from to power all the items that we need? Explain that most of the electricity we use in the US is created by burning coal. What is the problem with burning coal to generate electricity? Engineers must find alternative ways to create the energy needed to power our homes, schools, businesses, etc. Where else can we get energy from? (sun). Show students a solar panel. Ask students if they have ever seen one before? Where do you normally see them? (roof) Why? (get more sunlight). Connect the solar panels showing how it can be connected in a series to light a bulb. Explain that students will be designing a solar city using the engineering design process (understand the need, brainstorm different designs, select a design, plan, create, improve and repeat the cycle as necessary to conclude with an appropriate and acceptable engineering solution. Students will be placed in groups to design their solar city. After designing on graph paper, students will create their buildings, help from adults will be needed to cut foam boards and hot glue to cardboard. Students will then paint buildings, design parking lots, grass, etc. Finally, solar panels, bulbs, motors or buzzers will be placed on/in buildings. (Students can create fans using a pieces of plastic from a plastic bottle) Finally, attach solar panels to roofs using duct tape and connect wires to make series circuits. Place city outdoors in sunlight or use a 100-watt incandescent light to power their city. Have them observe what happens when the solar panels are tilted at different angles. What is the best positioning to generate the most energy? [3]

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